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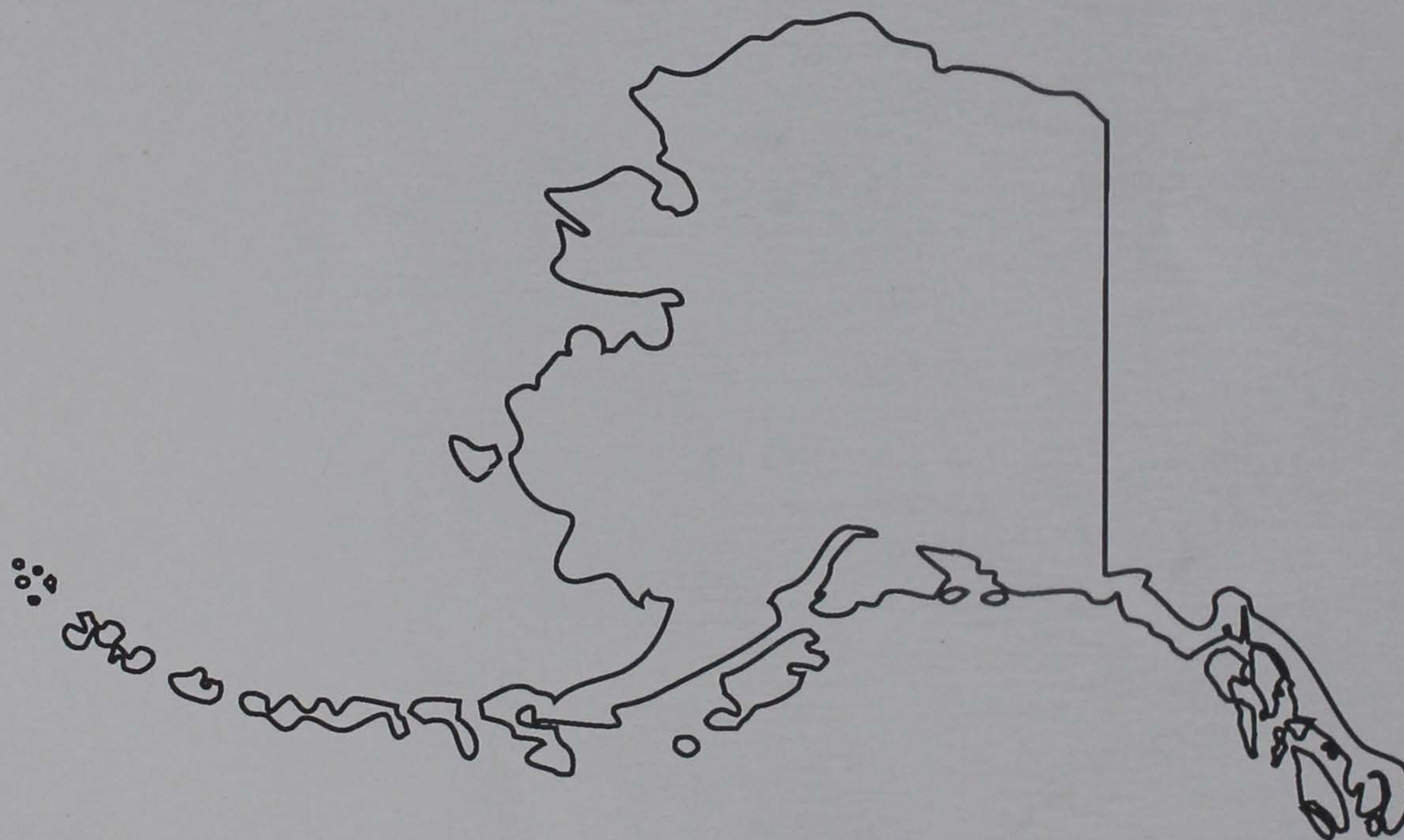
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May 1992



Forest Health Management Report

Current Knowledge of Ecology and Silviculture of
Yellow-cedar in Southeast Alaska: Information
Exchanged at Sitka, Alaska, November 1991



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Subject: Summary of yellow-cedar meeting

To whom it may concern:

Enclosed is a report that summarizes the discussions at a meeting held last November on the ecology and silviculture of yellow-cedar (*Chamaecyparis nootkatensis*). This report describes our current knowledge on various aspects of the biology and management of this valuable forest species, including its artificial and natural regeneration. I would like to thank all participants at the meeting for sharing their ideas and observations. A special thanks goes to Jon Martin for helping to organize and moderate the meeting.

Please contact me by phone (907) 586-8769, DG (P.Hennon:R10A), or mail if you have any questions or comments regarding forest decays, diseases, or yellow-cedar.

Paul Hennon

Paul Hennon
Pathologist

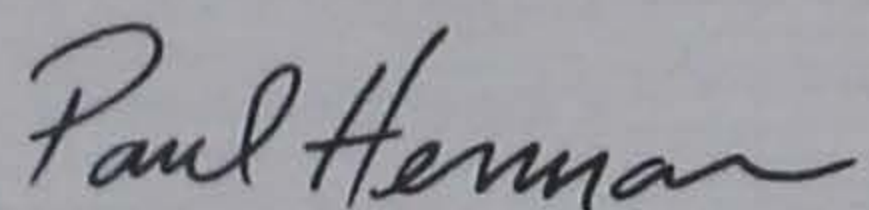
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General Technical Report R10 TP-24

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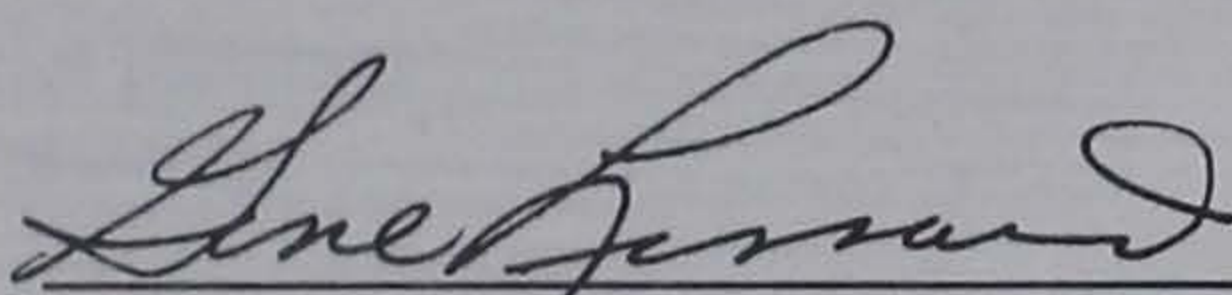
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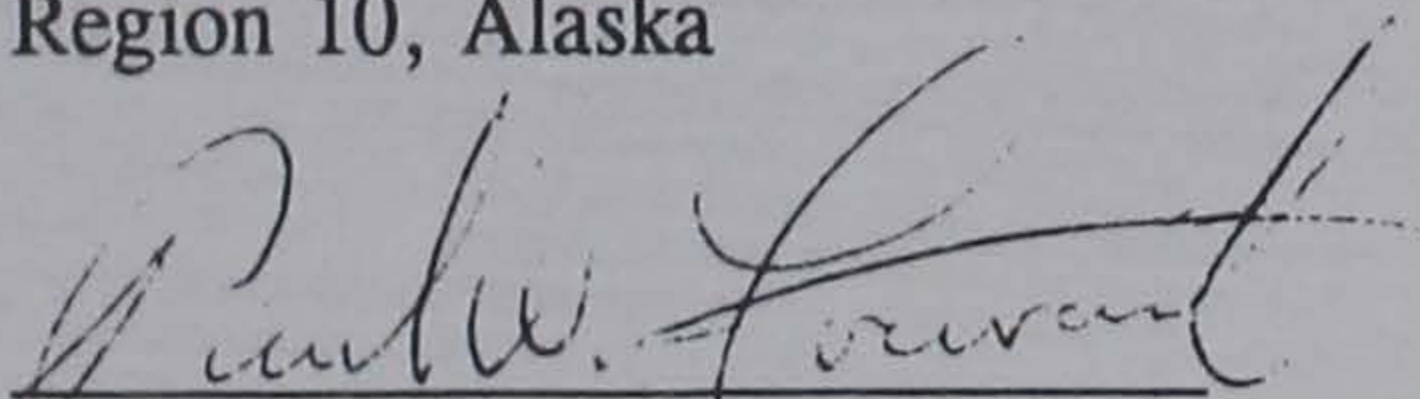


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TABLE OF CONTENTS

INTRODUCTION	1
Names and relatives	1
Longevity	3
Wood characteristics	3
Value and uses	4
Available literature	5
ECOLOGY OF YELLOW-CEDAR	6
Occurrence of yellow-cedar in plant associations	6
Occurrence by elevation	8
Natural reproduction by seed	8
Seed dispersal	9
Vegetative reproduction	9
Observations of natural regeneration in unmanaged forests	10
Summary of yellow-cedar's ecology	11
ARTIFICIAL REGENERATION--PRODUCING PLANTING STOCK	11
Seed production	11
Cone collection	12
Seed germination	13
Seedling production	14
Stecklings	14
PLANTING STUDIES	14
Anita Bay trials	15
Wrangell Ranger District plantings	15
Craig Ranger District plantings	16
ANIMAL DAMAGE	17
Deer browse	17
Bole wounding by brown bears	18
Voles and flying squirrels	18
Porcupines	18
CEDAR DECLINE	18
FUTURE MANAGEMENT CONSIDERATIONS FOR YELLOW-CEDAR	20
Why manage yellow-cedar?	20
Is current yellow-cedar regeneration meeting desired goals?	20
Methods to improve regeneration	21
Pruning and spacing	23
Research needs	23
What can we do now?	24
ACKNOWLEDGEMENTS	26
REFERENCES	27
APPENDIX A. List of participants	29
APPENDIX B. Field Trip Notes	30

Current knowledge of ecology and silviculture of yellow-cedar in southeast Alaska: information exchanged at Sitka, Alaska, November 1991

INTRODUCTION

Twenty resource specialists¹ met in Sitka for three days in November 1991 to discuss the ecology and silviculture of yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) in southeast Alaska. The primary objective of this meeting was to share information, ideas, and observations on yellow-cedar. Although cedar is an important tree species on the Tongass National Forest, resource managers, silviculturists, ecologists, and researchers had not met as a group to discuss its ecology and management. Most participants agreed that natural regeneration of yellow-cedar is less than desirable on harvested sites where yellow-cedar was an important component of the original forest stand. Thus, a large part of the meeting was dedicated to discussions on what factors limit natural reproduction of yellow-cedar and what silvicultural measures can be employed to improve natural and artificial regeneration. The meeting resulted in a focused list of research questions and a discussion of possible silvicultural techniques to consider in the future.

The purpose of this document is to report the various comments and information presented at the meeting. Many of the comments were based on casual observations or ideas and not detailed study. Because the research base on yellow-cedar is limited, these observations are extremely valuable. They are reported here because they are not likely to be documented anywhere else. So please be aware that what follows is a mixture of information based on the scientific literature and comments by observers with a good deal of experience in the forests of southeast Alaska.

The meeting began with an introduction of yellow-cedar that included discussion of names, natural distribution, wood characteristics, value, products, and subsistence use. Discussion from ecologists described what we have learned about the ecology and distribution of yellow-cedar from work on plant community analysis in the three Areas of the Tongass National Forest. The discussion then moved to natural regeneration in unmanaged stands and in cutover areas. Dialogue included details of yellow-cedar reproductive biology. We spent one-half day observing two even-aged stands dominated by yellow-cedar in the Sitka area. These stands apparently regenerated after timber harvesting by the Russians. They may provide a glimpse similar to the future appearance of yellow-cedar plantations. Back at the meeting, discussions began with decline and mortality of yellow-cedar and then moved to regeneration: three planting trials were presented followed by detailed discussions of cone collection, production of planting stock, and silvicultural methods to improve artificial and natural regeneration. Species management, that is, the desired species composition and condition over time, is an integral consideration when determining management actions. It is critical that this be considered by silviculturists developing site specific prescriptions as part of interdisciplinary teams and the NEPA process. The meeting concluded with a listing of research needs and potential strategies that participants can use now to improve the management of this valuable tree species.

Names and relatives.

The scientific name of yellow-cedar is *Chamaecyparis nootkatensis* (D. Don) Spach. The genus name, *Chamaecyparis*, is derived from "false-cedar." The species epithet, *nootkatensis*, describes the location, Nookta Sound on Vancouver Island, where Europeans first collected and studied the species. *Chamaecyparis* species belong to the cypress or cedar family, Cupressaceae. Members of this family should not be confused with the "true cedars" in the genus *Cedrus*, which belong in the Pinaceae and have long needles and large cones.

¹ See Appendix A for a list of the participants.

The genus *Chamaecyparis* is comprised of seven species worldwide (Table 1). Besides yellow-cedar, two other species are endemic to North America. Port-Orford-cedar (*C. lawsoniana* (Murr.) Parl.) has a small range in southwestern Oregon and the northwestern adjacent portion of California. Atlantic white-cedar (*C. thyoides* (L.) B.S.P.) grows in isolated stands in swamp regions along the Atlantic and Gulf coasts of the United States. Yellow-cedar has a natural distribution from Prince William Sound, south through coastal British Columbia, in high elevation areas through the Cascades in Washington and Oregon, and into the Siskiyou Mountains near the Oregon-California border (Harris 1990). The remainder of the genus is represented by two species each in Japan and Taiwan. The most commercially important of these latter species grows in Japan and is known as hinoki or hinoki cypress, *C. obtusa*. This species is prized by the Japanese and its appeal is deeply seated in their tradition and religion. Most Shinto temples and shrines in Japan are constructed of its wood (Sato 1973).

Table 1. Species of the genus *Chamaecyparis*.

Species	Location
<i>C. formosensis</i> Matsumura	Taiwan
<i>C. lawsoniana</i> (A. Murray) Parlatore.	NW California to SW. Oregon
<i>C. nootkatensis</i> (D. Don) Spach	N. California to Prince William Sound
<i>C. obtusa</i> (Siebold and Zuccarini) Endlicher	Japan
<i>C. pisifera</i> (Siebold and Zuccarini) Endlicher	Japan
<i>C. taiwanensis</i> Masamune and Suzuki	Taiwan
<i>C. thyoides</i> (Linnaeus) Britton, Sterns and Poggenberg	East Coast of United States

Members of the genus *Cupressus* are closely related to *Chamaecyparis* spp. and have similar round spiked cones, leaf scales, and aromatic heartwood. Incidentally, the heartwood of each species of the Cupressaceae has a pleasant and distinctive smell. The two genera are so closely related that hybrids have been developed through forced breeding. One such hybrid, Leyland cypress, is the result of a cross between yellow-cedar and Monterey cypress (*Cupressus macrocarpa* Hartw.). Leyland cypress is a fertile ornamental tree developed by the British for its cold-hardiness and is planted in many parts of the temperate world.

The common name of *C. nootkatensis* has recently come into question. The *Checklist of United States Trees* (Little 1979), which is sometimes used for official common names, lists the name "Alaska-cedar." But our colleagues from British Columbia, where the bulk of the volume of cedar occurs, take exception to calling the species "Alaska-cedar" and prefer the common names "yellow-cedar" or "yellow-cypress." Numerous other common names have been used in the past including Sitka-cypress, Alaska yellow-cedar, Nootka-cypress, canoe-cedar, and other combinations of these names. Because yellow-cedar is a false cedar, the common name should be hyphenated in the same way as Douglas-fir, which is a false fir. Presumably this should be the case for western redcedar. Although universal acceptance of the same common name is probably not important, most participants at our meeting appeared comfortable with the name "yellow-cedar."

Longevity.

Yellow-cedar is long-lived and has been compared to some conifers with the greatest longevity in the world. But information on tree ages, particularly in Alaska, is minimal. Somewhat more information on longevity comes from British Columbia. A 1,600 year-old yellow-cedar was found near Campbell River, B.C. (Jozsa 1990). Jozsa states that there are many trees that are potentially older whose age cannot be determined because of butt rot. One hollow yellow-cedar had 1040 annual rings in the outer one foot shell and had an estimated age of 3500 years (Perry 1954)! Very little information exists on the maximum age of yellow-cedar in Alaska. In studies on average-sized trees on poor and moderate sites, Paul Hennon (unpublished data) found most yellow-cedar trees to be about 150-400 years-old with 500-600 year-old trees being common. As in British Columbia, older trees in Alaska often have extensive heartrot which restricts determining maximum tree age.

Wood characteristics.

The wood of yellow-cedar has several outstanding characteristics that make it unique and valuable--it is a pale yellow color, tight grained (from old-growth trees), aromatic, and very decay resistant. The wood also has the useful combination of strength yet homogeneous density which allows it to machine very well. Nootkatin and several other chemical compounds impart decay resistance, the yellow color, and the pleasant aroma of yellow-cedar's heartwood. Sapwood generally lacks these characteristics and is not particularly decay resistant.

Although heartwood of old-growth trees has these valuable properties, questions have been proposed concerning whether the desirable wood characteristics of old-growth trees will be maintained in the faster growing young trees from managed stands. These concerns include the amount of heartwood produced, concentration of nootkatin and other compounds leading to decay resistance, occurrence of knots, wood density, and other effects associated with greater ring width. To the surprise of some, recent information suggests that young-growth trees can maintain most of the preferred wood characteristics.

On our field trip in Sitka, we observed that young-growth trees do produce a good volume of heartwood; the sapwood typically occurs as a narrow outer band. Detailed measurements in these and other even-aged stands could provide a measure of heartwood volume production in certain stand densities. The heartwood/sapwood ratio may be a characteristic that can be improved by controlling tree spacing in managed stands--tighter spacing of trees should lead to smaller crowns and, thus, proportionally less sapwood volume per tree.

In British Columbia, Jozsa (1991) has produced some noteworthy preliminary results from research concerning wood density. All western conifers have variation between the density of wood produced in spring (lower density) and that produced in summer (higher density), giving wood the appearance and feel of grain. The measure of this within ring density is called "density uniformity." But the

wood of yellow-cedar is unique in that the difference in density between spring (early wood) and summer (late wood) is very low; in fact, it is lower than any other conifer tested. This greater density uniformity increases wood strength and homogeneity and is a leading reason why yellow-cedar is one of the best woods for hand-carving anywhere. In recent comparisons between the wood of old-growth and young-growth yellow-cedar trees, Jozsa found that this unique feature of little variation in spring/summer wood density was maintained in fast-growing young growth trees.

Another wood characteristic of yellow-cedar that adds to its value and usefulness is its average wood density, which is about 0.42 g/cm³. Many have assumed that this would be one characteristic not maintained in wood from fast growing young-growth trees. Once again, the wood from young trees does not appear to differ from wood taken from old-growth trees. These results by Jozsa are preliminary; more detailed reporting from his research will document differences in wood properties from yellow-cedar trees growing in old-growth forests, 100-year old stands, and in fast-growing "off-site" (low elevation) plantations in British Columbia.

Thus, the assumption that wood from faster growing young-growth trees will not have any of the desired characteristics of old-growth trees is erroneous. The wood will have greater ring width, but surprisingly, most of the desired characteristics are not related to slow growth. In addition, wood from young-growth trees grown in southeast Alaska will have somewhat slower growth than the 1 cm/year ring width found in plantations in British Columbia. Clear wood (few knots) may be more of a problem in young, managed stands, but is a characteristic that can be altered by genetic selection, spacing, pruning, and other silvicultural techniques.

Value and uses.

The wood of yellow-cedar is typically the most valuable grown in Alaska. For example, Dean Argyle reports that the regional average for all grades of yellow-cedar in 1990 was \$631/MBF, almost all of which was export. Prices fluctuate widely between a low of about \$150/MBF for lower grades and in excess of \$3,500/MBF for peeler grade. Commercial availability is sometimes a problem in areas. To illustrate its value in coastal areas of British Columbia, wood from yellow-cedar in that region makes up about 7% of the volume but 14% of the value (Jozsa 1991).

Most of the yellow-cedar wood produced in both British Columbia and Alaska is exported to countries in the Asian Pacific Rim with the majority going to Japan. The Japanese prize the wood of their native *Chamaecyparis* species (hinoki), but since so little is currently available due to past harvesting, yellow-cedar has become a good substitute. Port-Orford-cedar is also in demand, but it is suffering from an introduced, devastating root disease pathogen that is limiting its management (Zobel et al. 1985). Yellow-cedar is not affected by that disease. Much of the yellow-cedar exported to Japan is used for post and beam construction and interior uses such as molding around doors and windows. A small portion of wood is used for the construction and restoration of religious shrines and pagodas. The wood in most demand for most uses is homogeneously light in color and free of stain or knots. The Japanese like to see enough grain to recognize the product as wood, but beyond that, they prefer wood to have as homogenous an appearance as possible. This is said to contribute to a calming environment.

Historically, Native people in coastal Alaska and British Columbia have used yellow-cedar for so many purposes that the term "cedar culture" has been used to illustrate its importance. This accounts for the use of both yellow-cedar and redcedar, the latter being especially important for canoe construction. The wood of yellow-cedar has countless traditional uses including canoe handles, totem poles, fish lures, dishes and many other familial items. In addition, the fibrous inner bark is also used. After soaking in salt water, pounding, and drying, it is woven into mats or hats, and used to

decorate masks, or prepared with mountain goat wool and woven into blankets or clothing. Large rectangular scars can be found on trees used for the collection of bark. Such subsistence or traditional use is still occurring; for example, Paul Hennon found numerous fresh scars on yellow-cedar trees at Cannery Point near Tenakee where bark had been removed recently.

The participants at our meeting discussed several non-timber values for yellow-cedar. As discussed above, its value in Native culture should not be overlooked. Also, trees and stands of yellow-cedar have value in terms of biological diversity. The forests of coastal Alaska have relatively small diversity of tree species and maintenance of appropriate species mixture is an important consideration. Yellow-cedar is a prime firewood due to the low moisture content of its heartwood; the aroma from its firewood use permeates many towns and villages in southeast Alaska every winter. Value of trees and stands of yellow-cedar to wildlife is not currently understood. The foliage of yellow-cedar provides important deer and moose browse in winter and bark is stripped by brown bears in spring in some local areas, but we don't know if yellow-cedar trees or their associated vegetation may have other unique wildlife uses. Also, old yellow-cedar trees may hold secrets of past climates in patterns of their annual growth. Thus, these old trees may be invaluable to research on climate change.

Thom Pence suggested planting and managing yellow-cedar to be used in punchion trail construction. Slabs of yellow-cedar wood, like thick roof shakes (not stakes), are split from rounds and placed upon areas of soft ground to support the trail traffic. If installed properly, the "shakes" can last four to five decades, whereas treated planks of other species may only last 15 to 20 years. Adjacently-grown yellow-cedar would be less expensive and avoid the need for machinery to carry materials to wilderness areas, and it does not have the associated toxic compounds needed for treatment. In addition, the possibility of using an on-site, natural product for trail construction is attractive.

There was some discussion that appraising volume and value of yellow-cedar could be made more precisely on the Tongass National Forest by improved methods of cruising yellow-cedar stands. One participant recommended that, because of its low volume but high value, yellow-cedar should receive at least the same (or more intense) cruising and grading considerations as hemlock and spruce. In some areas, John Stevens stated that yellow-cedar is appraised as "camp-run" and all logs are sold with the same value. No adjustments are made to the value even if the log grades are all peeler and select or if the lowest grade sawlog is all that is present. Under this procedure, most yellow-cedar is sold as #2 logs. According to Jerry Boughton and Dean Argyle, however, yellow-cedar logs are graded at the time of scaling. All scale grades are summed to establish the base selling value for the next year. This value is adjusted quarterly. Thus, value by grade is being realized.

Available literature.

The scientific literature on yellow-cedar is scattered, but several references provide a good place to begin searching for general or specific information. These references are briefly described below. More literature is cited at the end of this document.

Although no longer up-to-date, Harris' (1969) annotated bibliography of yellow-cedar is an excellent place to look for information on yellow-cedar. Harris describes 301 references on yellow-cedar, which he arranges alphabetically by author, and provides a short paragraph about each reference. A subject index at the back of the document can lead one to all references that treat a particular topic, such as rooting habit, longevity, or wood chemistry.

Perry (1954), Anderson (1959), and Harris (1971) provide brief treatments of the wood properties and silvics of yellow-cedar. This information has been updated by Harris (1990) in the recently published *Silvics of North America*. Be aware that the map for the natural distribution of western

redcedar was mistakenly used for that of yellow-cedar in some of the volumes of the latter work. Volumes with the correct distribution will have the map pasted on the page.

Representatives from industry, silviculture, and research who are interested in yellow-cedar have formed what is known as the "Yellow-cypress working group." The group is primarily composed of people from British Columbia, but several people from the U.S. also participate. Glen Dunsworth and Liz Steele of MacMillan-Bloedell in Nanaimo edit a newsletter (Dunsworth and Steele 1987-1991) that is published annually to describe new ideas, observations, and the latest research findings on yellow-cedar. The five newsletters published to date provide interesting reference material on yellow-cedar as well as good contacts of people working on specific aspects of the species' biology or silviculture. Write to Glen and Liz² if you want to receive future newsletters or if you want to contribute information to the group or its newsletter. Call or write to Paul Hennon if you want copies of the first five newsletters.

The yellow-cypress working group also held a workshop in Richmond, British Columbia on March 26-28, 1990 entitled "Yellow-cypress: can we grow it? Can we sell it?" The proceedings (Lousier 1992) offers interesting discussions about the ecology, pathology, management, wood products, and marketing of yellow-cedar. It summarizes the important new research on yellow-cedar being conducted in British Columbia. Paul Alaback and Paul Hennon attended the meeting and provided information about the biology of yellow-cedar in Alaska.

A group with a broader interest, that of the entire *Chamaecyparis* genus, has met several times, most notably in Massachusetts and in Yokohama, Japan. The group is somewhat dominated by the interests of Atlantic white-cedar, but has provided interesting comparisons among the various species. Glen Dunsworth and Paul Hennon contributed papers on yellow-cedar. A book (in press) summarizes ecological and silvicultural work on the various species. A paper in that book authored by Don Zobel of Oregon State University provides the first ecological comparison of the species of *Chamaecyparis*.

Paul Hennon has reprints, which are available upon request, that describe research conducted with several coauthors on cedar decline (Hennon 1990, Hennon et al. 1990a,b,c,d). These papers treat studies on symptoms of dying trees, fungi and other organisms on yellow-cedar, ecology and epidemiology, animal damage, and reproduction in natural stands. Results from this research is summarized below.

ECOLOGY OF YELLOW-CEDAR

Occurrence of yellow-cedar in plant associations.

Jon Martin, Tom DeMeo, and Bill Pawuk shared observations and data on the occurrence of yellow-cedar in different plant communities in the Chatham, Ketchikan, and Stikine Areas, respectively, of the Tongass National Forest. These results are part of the Alaska Region's Plant Association program. The discussion of plant communities is valuable because communities indicate much about the physical environment. As Jon described, "we can use vegetation to read the environment." Thus, we can learn something of the ecological preferences and requirements of yellow-cedar by comparing communities where yellow-cedar is absent, present, dominant, or experiencing decline. This

² Glen Dunsworth and Liz Steele, MacMillan Bloedel Ltd., 65 Front Street, Nanaimo, British Columbia, CANADA, V9R 5H9.

knowledge should improve the management of yellow-cedar for a variety of resource needs in the various communities in which it grows.

Jon Martin reported that yellow cedar competes best on mid- to low-productivity sites where it is tolerant of wet, poorly drained soils. It is abundant on these sites in two plant community types, the Mixed conifer and Hemlock-yellow-cedar associations. The associated vegetation in these plant communities confirms that yellow-cedar is most common on sites with poorly drained soils.

Tom Demeo's and Bill Pawuk's plant community data generally agreed with Jon's: yellow-cedar is well represented in the same two community series on wet sites. Tom DeMeo reported more variation in the occurrence of yellow-cedar by plant community types than appears to occur in the other two areas to the north; yellow-cedar is somewhat more common in some of the other plant community types in the Ketchikan Area. However, all three Areas had sites that appeared to be favorable for yellow-cedar, but where it was completely absent. This absence in apparently favorable sites has been reported by ecologists in British Columbia.

Paul Hennon presented results of sampling yellow-cedar forests on Chichagof and Baranof Islands. Using an ordination analysis technique, DECORANA, the basal area of the different conifer species present was compared to a vegetation gradient that ranged from open bog (muskeg), through an intermediate zone, to sites with good drainage. Yellow-cedar was the dominant tree species (measured by basal area) along the intermediate zone. It was present on poorer and better drainage, but was not dominant there. Although it was less common on the well-drained sites, individual yellow-cedar trees reached their greatest size in these forests. Total conifer basal area and average tree height increased steadily along the gradient towards better drainage. These results, which are consistent with those of the plant community typing work, indicate that yellow-cedar is tolerant of wet, poorly drained sites, but not so tolerant of the poorest sites as shore pine. Results also suggest that yellow-cedar is apparently competitive and well-adapted to sites with moderately poor drainage. The intermediate zone along the drainage gradient where yellow-cedar dominated would be the same Mixed conifer and Hemlock-yellow-cedar plant community types described above.

Tom DeMeo discussed factors that influence the distribution and regeneration of yellow-cedar in the Ketchikan Area. Major factors include 1) the occurrence of the Little Ice Age from about 1350-1870 A.D. (Pielou 1991), 2) deer feeding, 3) disturbance, and 4) "randomness" or the improbability of several unlikely events coinciding. The arrival and retreat of the Little Ice Age may have removed yellow-cedar from a more continuous range that it previously occupied. Perhaps it was favored by the cooler climate of the recent past or perhaps it was allowed to regenerate at a time when fewer deer were present to consume its seedlings.

Unfortunately, little is known of its distribution in relatively recent geologic time because its pollen does not persist as well as that of other conifers and it has been overlooked in studies of the abundance of tree species along the west coast of North America (Heusser 1960). The same is generally true for other species of the Cupressaceae.

Tom DeMeo also contrasted the concepts of survival and competition. Yellow-cedar is able to establish and grow on harsh sites, often excessively wet, where competition is minimal. On the more productive sites, it is often not able to compete with other tree species that seed more prolifically and have faster growth. This is consistent with Paul Alaback's (1992) view of the species as a stress tolerator that allocates a relatively high amount of energy to the production of defensive compounds.

Tom DeMeo and Jon Martin debated the importance of temperature and precipitation (respectively) in determining patterns of vegetation in southeast Alaska. Tom argued that in the Ketchikan Area temperature is the more important factor and slight differences in growing-degree days (necessary temperature for a given time) can affect the distribution of plants. Tom suggested that once you are wet, you can't get significantly wetter (a condition that we have all experienced). Jon described the extreme variation in precipitation that occurs in southeast Alaska from area to area. He believes that this variation affects the distribution of plants. Although unquantified, both temperature (by increasing or decreasing decomposition) and precipitation undoubtedly influence soil drainage, which has been shown to be the dominant factor in the distribution of yellow-cedar.

Occurrence by elevation.

Bill Pawuk mentioned that yellow-cedar reaches its greatest height and diameter at mid-elevation, often around 700-1500 feet on relatively good sites. As it is apparently adapted to colder temperatures, perhaps it is better able to compete in this zone than at lower elevations. Tom DeMeo compared the occurrence of western redcedar with yellow-cedar along an elevational gradient in the Ketchikan Area. Western redcedar is more common at lower elevations (and more confined there) and yellow-cedar is more common at mid-elevations, being most common at about 1,000 feet. Yellow-cedar appears to be less confined to any elevation. Perhaps the concentration of redcedar at lower elevations in this area is not surprising for a species that is relatively close to the northern end of its natural distribution. It may be limited by growing degree days further north and at higher elevations. Jon Martin reported that yellow-cedar is more common at higher elevation in the southern portion of the Tongass National Forest than further north. It can occur near timberline, however, in all areas of the Tongass National Forest.

Regardless of elevation, Tom DeMeo found redcedar to be more concentrated on better-drained soils than yellow-cedar in the Ketchikan Area. Tom suggested that redcedar competed better on these sites because it seeds more prolifically.

Natural reproduction by seed.

The success of natural reproduction undoubtedly has a major role in determining the distribution of yellow-cedar in different plant communities and in different geographic areas. Many discussions of yellow-cedar state that it is limited to poor sites because it is too slow-growing to compete on productive sites with faster growing conifer species. But where it mixes as a minor component on these sites, it appears to produce good growth. Perhaps factors that influence natural reproduction are the primary reasons that the species has an inconsistent occurrence in the forests of southeast Alaska.

Jon Martin described an hypothesis that may explain why more natural reproduction is not found in the forests of southeast Alaska. This became known as the "Martin Hypothesis." Essentially, Jon argued that deer browsing has reduced yellow-cedar's ability to regenerate at most locations. If this is true, then deer are exercising a surprising control over the development of forest composition. The foliage of yellow-cedar is known to be a desirable winter food for deer. For example, deer browse is heavy on the yellow-cedar plantation established by Paul Hennon at Anita Bay (see below), although little mortality was directly attributed to browsing. The three known even-aged stands that regenerated to yellow-cedar (two in Sitka and one at Cannery Point near Tenakee) may have had deer removed by unregulated hunting as red meat was in great demand at that time. The establishment of existing old-growth yellow-cedar forests, which are now comprised of century-old trees, may be explained (hypothetically) by their initiation during colder climates when there was a more consistent winter snow pack and deer were uncommon or absent in most areas.

Some evidence suggests that deer feeding is not the only or primary factor limiting natural regeneration of yellow-cedar. Yellow-cedar is not regenerating in deer-exclusion areas established by Paul Alaback near Hoonah. These exclosures are designed to determine the influence that deer have on establishing vegetation and occur on harvested sites where yellow-cedar was common in the previous stand. Also, several participants described that yellow-cedar is not establishing in many disturbed areas (natural disturbance or clear cuts) in areas of low or non-existent deer populations. Some areas, such as portions of Kuiu and Kupreanof Islands, have minimal deer populations and cedar still does not regenerate well.

Perhaps a greater frequency of fire in the past compared with recent times aided natural regeneration of yellow-cedar. The Cannery Point site apparently regenerated heavily to yellow-cedar following a fire. Tom DeMeo reported a number of sites in the Queen Charlotte Islands and southern Prince of Wales Island where yellow-cedar regenerated after fires around the time of 1900.

Paul Hennon reported two studies to better understand reproduction of yellow-cedar in unmanaged stands. First, the fate of several hundred 1 and 2 year-old naturally reproduced seedlings were monitored for 3 years in a high-volume cedar forest on Chichagof Island. Incidentally, newly germinated seed of yellow-cedar can be distinguished by having two cotyledons; other conifer species have more (western redcedar also has two). After three years, no seedlings survived. Apparently, seed is produced, a small number of seeds germinate and grow into one or two year-old seedlings, but very few survive beyond that stage. Some of the killed seedlings had been eaten or disappeared, but most just shriveled and died. It is possible that yellow-cedar is shade intolerant and needs a major canopy disturbance (not present on these sites) which exposes the understory to light to permit successful regeneration.

The occurrence of yellow-cedar seedlings was also followed along the bog to better drainage gradient in unmanaged forests by the methods described by Hennon above. Seedling abundance paralleled the basal area of yellow-cedar on these sites, perhaps merely indicating the availability of seed. The close relationship between basal area and seedling abundance may reflect a short dispersal distance for yellow-cedar seed. Almost all seedlings found were small and one or two years old. Older, established seedlings were uncommon and saplings could not be found in these areas.

Seed dispersal.

The dispersal distance for seed of yellow-cedar is thought to be relatively short, normally less than 120m (Fowells 1965). As Bill Pawuk pointed out, the short distance is probably the result of the small wings on seeds (Owen and Molder 1984). This factor should be considered in any attempt of leaving seed trees of yellow-cedar to encourage natural regeneration.

Vegetative reproduction.

Paul Hennon described the habit of yellow-cedar to reproduce vegetatively on boggy sites in southeast Alaska. Antos and Zobel (1986) described the formation of adventitious rooting of yellow-cedar in tephra deposits following the explosion of Mt. St Helens in Washington. In southeast Alaska, clumps of low-growing, prostrate yellow-cedar are very common on many muskeg sites. A number of these patches of low-growing yellow-cedar were excavated to understand how they were reproducing. All stages of layering (the adventitious rooting of lower limbs) were found. Upright, adjacent stems of yellow-cedar often share the same root system. They are usually connected by a former limb growing along the ground which produced adventitious roots. Sometimes, this connection dies, and eventually decays away. Thus, these clumps are continuously, but slowly, spreading in an asexual manner horizontally along the ground. Stem radial growth is very slow on these small yellow-cedars -- a

number of 1.5-2.0 inch diameter specimens were found to be 120-150 years of age. Their genetic (clonal) age may be remarkably old!

Seedlings, distinguished from layering by their immature foliage, were sometimes found in and near these layering clumps. They too began the layering process once their lower limbs began to root adventitiously. On some sites, the stems of layer plants appeared to turn upright and begin to grow into trees, perhaps a response to improved drainage.

In sampling on Baranof and Chichagof Islands, this form of layering was extremely common on wet, poorly drained sites in muskegs but was not found in forests on better drainage. Lower limbs do not contact the ground and thus cannot root in these forests with larger trees and closed canopies.

Observations of natural regeneration in unmanaged forests.

Participants reported the areas where they have seen natural reproduction by yellow-cedar in unmanaged forests around southeast Alaska. Clearly, we can learn something about the requirements of yellow-cedar regeneration if we investigate where it is effective and contrast the environmental factors there with where it fails to successfully regenerate.

Reporting for the Stikine Area, Bill Pawuk described observing young yellow-cedar seedlings on moss on the ground in forests, but not on logs or mossy logs in the forest. He has also seen yellow-cedar seedlings on the hottest, driest areas, such as south-facing roadcuts with extremely well-drained substrate. An interesting research study from British Columbia determined that yellow-cedar has one of the most sensitive controls of its stomata of any conifer tested (Grossnickel 1992). Apparently, yellow-cedar is able to close stomata and tolerate very dry soil conditions. This is another physiological characteristic of yellow-cedar that does not seem particularly intuitive to us; the species is known for dominating wet, poorly drained sites (at least in the northern part of its range) where soil moisture is not often lacking.

Tom DeMeo reported that yellow-cedar does regenerate on areas that have soil disturbance in the Ketchikan Area such as road cuts and landings. Its natural regeneration on avalanche tracks is not known. Paul Hennon has looked for yellow-cedar regeneration unsuccessfully in avalanche tracks on Chichagof Island. Perhaps seed source is limiting or deer are consuming seedlings in these latter areas.

For reasons not understood, Paul Hennon found seedling establishment by yellow-cedar to be abundant in a low volume, unmanaged, mixed conifer stand near Five Mile Creek on Kupreanof Island north of Petersburg. At that site, seedlings are establishing and growing into saplings successfully. Deer occur in the area as they are consuming seedlings planted around dying yellow-cedars in a study to document spread of cedar decline. This site appears to be similar floristically with the scrub sites on Baranof and Chichagof Islands where regeneration was poor. Other situations where Paul Hennon has encountered natural regeneration of yellow-cedar from seed are in bogs, creek outwashes, roadcuts, exposed soil near windthrown trees, earth slides, and cutover areas. Hennon stressed that, although seedlings were found in these areas, they were not typically numerous or consistently found at such places.

Tom DeMeo described his view of reasons for the limited yellow-cedar reproduction. Tom stated that the species has limited reproductive success because of the unlikely probability of coinciding factors that are necessary: adequate yellow-cedar seed production, lack of seed from competing vegetation (e.g., hemlock, spruce, alder), soil and canopy disturbance, and animal browsing.

Summary of yellow-cedar's ecology

Thus, a rudimentary understanding of yellow-cedar's ecology is emerging from these observations. Yellow-cedar is a species that is tolerant of cold, poorly-drained sites. For reasons that we do not know, it is not very competitive reproductively on more favorable sites. Many have assumed that the species cannot compete in growth with hemlock and spruce. But, perhaps, limited reproduction is the primary factor that explains its uncommon occurrence on productive sites. Clearly, we need to know more about seed production, seedlings' requirements of light and soil disturbance, and the impact of deer feeding. When trees do establish on better sites, good growth and size can be achieved. This indicates that we should be able to establish yellow-cedar on moderately productive sites to meet some resource values and, if we use artificial regeneration techniques, we may be able to grow yellow-cedar on well-drained productive sites to achieve timber-value goals.

ARTIFICIAL REGENERATION--PRODUCING PLANTING STOCK

Currently, planting stock of yellow-cedar used on the Tongass is derived from seeds and cones collected by Forest Service personnel. Seed is cleaned in Petersburg, stratified, and grown as containerized stock in contracted nurseries in the Pacific Northwest. Because of some peculiar characteristics of yellow-cedar, the two biggest hurdles in this process are collecting sufficient seed and attaining high and consistently timed germination rates.

Seed production.

Yellow-cedar is somewhat unusual in that seeds and cones take a year longer to ripen than most other conifer species (except shore pine) in southeast Alaska. As many participants at our meeting had observed, branches of yellow-cedar often bare two classes of cones--those that will shed seeds at the end of the coming summer and those that will shed seeds a year later. In late summer, these cones are about the same size, but green and brown respectively. In the southern part of its range, yellow-cedar often produces seed a year faster than in the north and therefore, has only one age class of noticeable cones. El-Kassaby et al. (1991) showed that cone and seed development is under environmental control as they transplanted and moved yellow-cedar to warmer low elevations in British Columbia where viable seed was then produced a year faster.

Bill Pawuk described that seed production actually develops over three growing seasons for yellow-cedar in southeast Alaska. Weather events in spring trigger the initiation of flower buds. Cones emerge from these buds the following spring at which time pollination by wind occurs. Most conifers, including Sitka spruce and both hemlock species in southeast Alaska, produce and disseminate seeds at the end of the summer following pollination, one and a half years after flower initiation was stimulated. Cone and seed development for both yellow-cedar and shore pine take an additional year. The same weather events appear to stimulate heavy cone crops for all of the conifers. Thus, one year after heavy cone crops by spruce or the hemlocks, good cone crops by yellow-cedar could be expected.

Bill Pawuk reported that yellow-cedar does not produce as much seed as Sitka spruce, western hemlock, or western redcedar. Perhaps this is consistent with yellow-cedar's suspected ecological strategy -- tolerance, longevity, and reduced reproductive capacity. Bill has observed particularly low seed production in cones on yellow-cedar at higher elevations. Jerry Jordan observed that same minimal seed production by yellow-cedar at elevations around 1500 ft on the Wrangell Ranger District. Bill warned that this may present difficulty in collecting sufficient seed to establish plantations at higher elevations.

The abundance of seed can be influenced by birds. Predation on seeds by birds is greatest during years when cone crops are heavy. Peak cone crops apparently attract birds that might not otherwise spend as much time feeding in southeast Alaska. Bill Pawuk commented that heavy cone crops by Sitka spruce and western hemlock might attract more birds and once seed supplies of these species are exhausted, the additional birds may cause greater losses in less-preferred species such as yellow-cedar. Feeding by squirrels also reduces potential seed for seedlings. The actual effect of predation by birds and squirrels on yellow-cedar seed is not known.

Bill Pawuk suggested growing yellow-cedars in large containers or growing them in hedges and applying hormones to induce and greatly increase cone production. Bill attempted this several years ago with good success on potted saplings growing in the Petersburg nursery. For now, however, planting stock will be produced by gathering seeds and cones collected from trees with desirable phenotypic characteristics growing in natural stands around the Tongass National Forest.

Cone collection.

Bill Pawuk reported that seeds of yellow-cedar mature in cones by early September in southeast Alaska. Natural seed release occurs in late September and October. The optimum time to collect cones with mature seed for yellow-cedar is probably around mid- to late-September. District and Area personnel are responsible to monitor seed development closely to ensure that appropriate levels of seed are developing to warrant a collection program for that year. Cone picking should occur when seeds are almost fully expanded (filled >90% of seed cavity) in their cones. For more information regarding planning and implementing a collection, refer to *A Guide to Collecting Cones of British Columbia*, FRDA Report 005 and FSH 2409.17--Silvicultural Practices Handbook, Chapter 4.

The group discussed the possibility of contracting the collection of yellow-cedar cones. Several Ranger Districts indicated that they do not have the time to collect cones because of their minimal staffing. One suggestion was to have District personnel mark trees for cone collection and have contractors make the actual collections. Jay Kittams expressed concern that since collecting good phenotypes for timber quality is so important that Forest Service personnel should do the cone collecting.

For safety reasons, cone collection by falling trees is advisable over having Forest Service personnel or contractors climb trees. Trees can be felled near roads where they may be utilized or cone collectors can visit harvest sites where trees have already been fallen. Jerry and Bill suggested using devices known as "blueberry pickers" or "cone racks" to speed the collection of cones from yellow-cedar trees.

Several participants commented that tree selection is critical when collecting cones of yellow-cedar. This will be the primary tool in genetic improvement under our current method of raising planting stock. Thus, great care should be exercised in selecting yellow-cedar trees that have desirable traits. Bill Pawuk suggests that each seed lot should consist of cones from about 20 trees from one area. Trees that have good general form, little twist, minimal lower branch retention, and good growth rates should be sought. Since surviving yellow-cedar trees can often be found on sites with intensive cedar decline, there is the opportunity to gather cones from these yellow-cedars and, potentially, their progeny could be more resistant to the primary factor causing cedar decline.

In the future, cones of yellow-cedar will be collected by each Area or District for their own use. A 10-year seed plan form is maintained by each Forest/Area. These plans should be kept current for all species and will serve as a basis for collection programs. Jerry Boughton stated that funds are

available from the Regional Office for cone collection to meet these identified needs. Once cones are collected, they should be stored and shipped in burlap bags. Each collection (seed lot) should be separate. Tags on burlap bags should express all of the information about the collection. Jay Kittams recommended that the information about the site (e.g., location, elevation, plant community) and the trees (e.g., size dimensions, form) should be recorded during cone collecting and records maintained. This would not require much time and is necessary so that we know the genetic basis of yellow-cedar that we are planting and can better match seedlings with sites and management objectives. Collections of cones will be sent to the Petersburg Ranger District, where seed will be extracted from cones, cleaned, stored, and sent to contracting nurseries for seedling production.

Seed zones (the extent in which planting locally collected seeds is advisable) have not yet been determined for yellow-cedar, thus, there are no guidelines for how far from the seed source planting stock can be used. One suggestion was to use Forest Service Districts as seed zones. District personnel could further stratify their area by into zones by elevation or by other parameters. Direction specifying cone tagging procedures and appropriate seed zones is currently being developed for FSH 2409.17--Silvicultural Practices Handbook, Chapter 4 and will be issued during the next year.

Jerry Boughton recommended that electrophoresis be used on different collections of yellow-cedar seeds to show their range in variation when sufficient seed collections are made. This technique can reveal the presence or absence of differently charged molecules and thus could provide a measure of genetic variation within and among seed collections. Electrophoresis will thus be explored to test and refine existing seed zones for yellow-cedar once more seed collections are made.

Seed germination.

Seeds of most conifers in southeast Alaska germinate readily in the spring following dispersal. But, in the natural setting, seeds of yellow-cedar remain on the ground, apparently dormant, for an additional year before germinating. This delayed germination probably reduces yellow-cedar's ability to compete with other tree species that quickly colonize disturbed sites. In the past, this factor also presented problems to silviculturists and others that expect to conveniently produce planting stock from the seeds that they collect.

Bill Pawuk presented data from work that he conducted on germination trials of yellow-cedar seed while he managed the Forest Service nursery in Petersburg. Without any stratification, Bill found that the time of seed sowing affects the percentage of seeds that eventually germinate in the greenhouse. Sowing followed by a warm period and then a cold period improves germination. Seed sowing in September produced the best germination, where no stratification was used.

But stratification can greatly improve the percentage, speed, and consistency of seed germination. The best stratification procedure is of warm, followed by cold, and then sowing. Thus, seeds can be collected, cleaned, and stored until needed. They can be removed from storage and stratified at room temperature for 60-90 days; followed by 90 days of cold stratification; and then sown. This stratification schedule appears to fit nicely with the timing of cone collection and seed sowing by the contracting nurseries. Cones can be collected in September and October, at which time seeds can be extracted and cleaned. They can then be stratified at room temperature and shipped to contracting nurseries. Personnel at nurseries can continue the warm stratification period if needed, move seed to cold stratification, and then sow in the spring. Thus, the problem of delayed germination is remedied by stratification and, with some effort, no time is lost between seed collection in fall and sowing the following spring.

Seedling production.

Once seeds of yellow-cedar germinate, growing them into seedlings is relatively straightforward. Containerized seedlings have been the only form of producing stock for yellow-cedar plantings in southeast Alaska. Seedlings are typically grown as 1-0 or 2-0 stock before planting. In the past, seedlings were grown in the Forest Service nursery in Petersburg. Now that the nursery has closed, yellow-cedar seedlings are being grown by contracting nurseries in the Pacific Northwest.

Yellow-cedar seedlings do not typically develop root-bound problems in their containers and survive well in storage. By contrast, problems have developed in the production of containerized stock of western redcedar. Fine roots of redcedar grow into small crevices of styrofoam. When seedlings are removed from their styrofoam cells, much of the root system is ripped and damaged. Bill Pawuk reported that altering the surface of styrofoam or using plastic cells will reduce this problem for western redcedar.

Jerry Boughton reported the number of yellow-cedar seedlings produced for planting on the Tongass National Forest from 1991 to 1993. In 1991, 29,000 seedlings were produced for planting in the Stikine Area; in 1992, 36,000 seedlings will be produced, 5,000 for the Chatham Area, 31,000 for Wrangell Ranger District; and in 1993, an estimated 20,000 seedlings will be available for planting at locations to be determined including 18,000 for the Wrangell Ranger District and 2,000 for the Chatham Area. All of this planting stock is derived from seeds collected on the Wrangell and Petersburg Ranger Districts several years ago when more than 600,000 seeds were collected.

Stecklings.

Largely because of the difficulty of collecting cones and the inconsistent seed germination, almost all yellow-cedar planting stock in British Columbia is now produced from vegetative cuttings. Yellow-cedar is viewed as a species with high economic priority by several forest companies there and demand for planting stock is great. In the past several years, an average of about 900,000 "seedlings" have been planted. But most were not seedlings, they were "stecklings," the result of vegetative rooting. Hedgerows of yellow-cedar are grown from the seeds of superior trees. Each year, small shoots are removed from the hedgerows, dipped in rooting hormone, and placed in typical containers. After one year of growth, stecklings closely resemble seedlings in appearance. Recently, Karlsson and Russell (1990) compared the growth of stecklings and seedlings of yellow-cedar in British Columbia for up to 11 years after planting and found no significant differences.

One advantage of using stecklings is the increased genetic control. On the other hand, the genetic base of planting stock is reduced unless sufficient numbers of hedgerows are grown. This could be a severe drawback for the use of stecklings. The use of stecklings takes more commitment and a longer planning schedule than the use of seedlings, particularly for the initiation of hedgerows. Stecklings may also be more expensive -- one participant reported that costs would be about \$170-180/1000 stecklings compared to our current costs of about \$130-150/1000 seedlings. Because of the decreased genetic base and increased costs and planning efforts, most participants felt that there was no compelling reason to switch to the use of stecklings for yellow-cedar planting stock at this time.

PLANTING STUDIES

Several planting studies of yellow-cedar seedlings have been attempted in southeast Alaska. The planting at Anita Bay was the first and attempts to answer questions about survival and growth on different site types. The Wrangell Ranger District is the leader in operational plantings of yellow-cedar. They are using seedlings grown from seed collected on their Area and have conducted several

large plantings on Etolin and Zarembo Islands. More planting is expected in the future. The Craig Ranger District conducted a unique planting of both yellow-cedar and Sitka spruce at higher elevation (about 1800 feet).

Anita Bay trials.

Paul Hennon planted seedlings of yellow-cedar in the Anita Bay area of Etolin Island in 1986 and made annual measurements to evaluate their survival and growth on different site types and different microsites (Hennon 1991). Blocks of 50 seedlings were planted at 16 sites that had some combination of poor, moderate, or good drainage and shade or good light exposure. Several hundred additional yellow-cedar seedlings were planted at Unit 1 near Anita Bay and now appear to be growing into a small stand of nearly pure cedar.

Seedlings in the wettest (bogs) and darkest (closed hemlock canopy) types had poor survival and little growth. The latter suggests that yellow-cedar is not particularly shade tolerant. The best survival (over 90%) and growth was achieved on clearcut sites that were burned, followed closely by clearcut sites that were not burned (differences were not significant). Both of these site types had good soil drainage and light exposure. In 1991, six years after planting, some seedlings on these sites had grown into saplings over six feet tall. Survival was also good (about 90%) on sites with moderate drainage, but growth lagged (significantly) far behind that of seedlings on the more productive clearcut sites.

The incidence of the shoot blight fungus, *Apostrasseria* sp., increased each year and began to cause minor damage on seedlings, especially on sites with endemic yellow-cedar nearby. Research is needed to demonstrate pathogenicity and describe this new species of fungus. Grazing by deer was greatest on the burned clearcut sites, but was also common on several other site types. Since deer only feed on recent foliage, most deer browsing did not cause seedling mortality. Deer browsing may, however, reduce growth and allow competing vegetation to engulf the seedlings.

This study suggests that yellow-cedar can be successfully established by planting seedlings. Based on these results, suggestions during development of site-specific silvicultural prescriptions are:

1. Seedling survival and growth appear best on sites with good soil drainage and light exposure.
2. If significant vegetation competition is expected, site preparation to retard competing vegetation (e.g., burning) or seedling protection to maximize growth (e.g., vexar) should be considered.
3. Burning will likely increase browsing if deer are present.

Wrangell Ranger District plantings.

The Wrangell Ranger District has planted far more yellow-cedar than anyone else in southeast Alaska. Much of what we will learn about successful regeneration of yellow-cedar in the near future will be from their experience.

Jerry Jordan presented information on recent operational plantings on the Wrangell Ranger District. As a brief experiment in 1989, cuttings were taken from yellow-cedar and placed directly into the ground to determine if they would produce roots. None survived. In 1990, yellow-cedar seedlings were on Etolin Island in two areas: 16 acres were planted in a 16' x 16' spacing with 1-0 stock and 137 acres were planted in a 19' x 19' spacing with 2-0 stock. Western redcedar was planted in other units that year. These plantings were conducted in mid-summer, which was unusually warm and dry in 1990. Survival was probably affected by the dry weather, timing of planting, and size of yellow-cedar seedlings as the 1-0 stock had 80% survival after one year and the 2-0 stock had only 50-60%

survival. There was some evidence of deer feeding, but most seedlings appeared to die from drought or transplant stress as a result of the dry weather. A small amount of mortality was caused by the selection of overly wet microsites.

More yellow-cedar seedlings were planted in May and June of 1991 at two locations on Zarembo Island: 44 acres at about 500 ft elevation and 56 acres at about 1200 ft elevation. Seedlings were planted at 20' x 20' spacing and fertilized at both locations. Because of high deer populations on Zarembo I., all seedlings were protected with vexar fixed with bamboo stakes. Survival after the first summer was 95% and 99% for the 44 and 56 acre plantings, respectively. In addition, a four-acre unit was planted to yellow-cedar on Wrangell Island with 14' x 14' spacing and no vexar or fertilizer treatment in July, 1991.

Beginning in May 1992, the Wrangell Ranger District plans to plant yellow-cedar seedlings in clearcuts occupied previously by yellow-cedar stands on Zarembo Island. Plantings will consist of a 64-acre unit with 15' x 15' spacing, a 68-acre unit with 20' x 20' spacing, and a 58-acre unit with 17' x 17' spacing.

Jerry Jordan expressed some concern that fertilization may make seedlings more attractive to deer. Jerry Boughton mentioned that this has been recently confirmed. Currently, the fertilizer consists of large, slow-release tablets. Several participants questioned whether fertilization helped speed growth and one asked whether we should be using petroleum products in this manner. Several mentioned that we need to establish controls to determine any benefit from fertilizing. John Stevens plans to conduct planting next year on the Wrangell Ranger District where yellow-cedar seedlings receive appropriate vexar, fertilization, and control treatments so that we can begin to quantify the benefits of vexar and fertilization.

Craig Ranger District plantings.

Annette Anderson presented information on a planting of yellow-cedar seedlings at an elevation of about 1800 feet near Polk Inlet on Prince of Wales Island, Craig Ranger District. The planting occurred in spring, 1990 on about 10 acres of a south-facing slope on a unit of Tolstoi soil type, a well-drained higher elevation soil derived from colluvium and residuum. The site had been clearcut and burned before planting. Yellow-cedar seedlings were interplanted with seedlings of Sitka spruce, which should provide an interesting comparison of survival and growth. Seed source was from the Stikine Area.

Feeding by deer on seedlings is minimal thus far; perhaps browsing will be less of a problem for yellow-cedar at higher elevations. The winter population of deer in this area is not known. Seedling survival is excellent, around 90%. Seedlings have produced little growth, but it is typical for seedlings to grow only minimally in height and stem diameter for the first year or so. For example, the yellow-cedar seedlings that eventually had fast growth at Anita Bay showed very little growth the first year after planting. Competing vegetation may present the greatest threat to the survival of the planted yellow-cedar and spruce seedlings on this site. Salmonberry appeared to sprout profusely and grow quickly following the burn. The Craig Ranger District plans to monitor seedling survival and growth annually, which is important since this is the only yellow-cedar planting trial at middle or higher elevations in southeast Alaska. Such areas may receive more logging and management in the future.

ANIMAL DAMAGE

Deer browse.

Yellow-cedar seedlings are an attractive source of winter food for Sitka black-tail deer. In some areas of high deer population, deer browse may be the limiting factor in survival and growth of planted or naturally regenerated seedlings. As described earlier, deer browse may contribute to yellow-cedar's sporadic colonization of disturbed sites such as clearcuts. Deer feed primarily on recently-grown foliage and shoot material of yellow-cedar. Young seedlings are sometimes killed by this feeding; some seedlings planted by Paul Hennon on Kupreanof Island in part of a study to document the spread of cedar decline were killed by deer feeding (Hennon, unpublished data). Terminal and shoots are fed upon in older seedlings but direct mortality may only result when these older seedlings are fed upon in several consecutive years. The most serious consequence of deer feeding may be that it reduces seedling size and allows seedlings to be engulfed by competing vegetation; more work is needed to confirm this idea.

Feeding injury on yellow-cedar saplings by moose was observed at one location in the Stikine Area where saplings had a very bushy appearance but were not killed. Because of the limited distribution of moose, this form of injury will not be widespread in southeast Alaska.

Bill Dougan commented that both sexes of deer may feed on cedar foliage for calcium; bucks need calcium for antler growth and does for depletion of calcium due to lactation. The same may be true for moose. Most cedar species tend to assimilate calcium in their foliage and other tissues. John Stevens suggested that yellow-cedar may be among the cedar species that does not assimilate calcium.

Browsing by deer on yellow-cedar may be more of a problem in the northern portion of the Tongass where deer have often already consumed most of their preferred browse species. In the Stikine Area where lower deer populations occur, preferred deer browse is often abundant, and less feeding on yellow-cedar may be expected. Tom DeMeo reported the same abundance of forage, including western redcedar, for the Ketchikan Area.

Several participants wondered how the vexar and bamboo stakes, which are used to protect yellow-cedar seedlings planted by the Wrangell Ranger District, would hold up to snow loads and snow creep during winter. Jerry Jordan and John Stevens will monitor vexar and bamboo stakes and see if they were displaced after their first winter. One participant suggested using wood survey stakes instead of bamboo for supporting vexar. Jerry Boughton confirmed that operational experience has shown this to be the state-of-the-art method for vexar installation in areas with significant snowload or where snow creep may occur. Tubes are anchored to the stakes with 2 to 3 twist ties. Others expressed concern that vexar might have to be physically removed from seedlings because it would not break down quickly in our cool climate and low light levels. Jerry Boughton described that old forms of vexar often persisted too long, but that vexar can now be ordered in several heights and for differing times of duration. Vexar is designed to disintegrate by ultraviolet light breaking chemical bounds. Since ultraviolet light penetrates cloud cover, the duration of vexar stated by the manufacturer may apply fairly closely to its use in southeast Alaska.

Most participants at the meeting seemed to agree that deer control, or any other silvicultural technique, should be tailored to the site as the silvicultural prescription. Thus, protection for seedlings, such as the use of vexar, may be appropriate for some sites, but not necessary on others. One participant suggested planting, monitoring the level of deer browse on seedlings after one year, and then making a decision of whether or not to use vexar based on the level of damage. Until we have more information, this appears appropriate since seedling mortality does not usually result from deer browsing.

Bole wounding by brown bears.

Brown bears cause substantial basal scarring on yellow-cedar trees in several areas of Baranof and Chichagof Islands (Hennon 1990). In surveys from these areas 49% of yellow-cedars had basal scars. Other conifer species do not have this form of wounding. Understory plant analysis reveals that the incidence of tree wounding is greater as the productivity of the site increased. Fresh scars consistently have bite or teeth marks produced as brown bears rip bark away from tree boles. Scars are located only on the lower boles and are produced in May and June, when bark is easily removed and the cambium is rich in sugars. Few trees are killed by this wounding, but some yellow-cedars, especially those along bear trails, are repeatedly scarred. Old scars have associated columns of wood decay in the valuable butt logs, which represents substantial economic loss if these stands are managed for timber production.

Bole scarring of yellow-cedar by brown bears appears to be uncommon in most other areas. This form of wounding has not been reported on islands inhabited by black bears. Thus, we may not anticipate bole wounding in future cedar plantations in most areas, but it could become common in some areas of the Sitka Ranger District.

Voles and flying squirrels.

Pat Tierney reported damage by voles on cedar regeneration on Heceta Island. Voles climb small trees and girdle the bole killing the tops. More damage was observed on western redcedar than on yellow-cedar. Paul Hennon has observed dead tops in sapling and pole-sized western redcedar at several locations on the Ketchikan and Stikine Areas. Damage was speculatively attributed to flying squirrels.

Porcupines.

Porcupines cause damage in young-growth stands in many areas within their range in southeast Alaska. For timber values, it is fortunate that porcupines are absent on many major islands. Where they cause damage, bark is consumed from the tops or along the entire bole of young trees or on the basal portions of larger older trees. Spruce and western hemlock are preferred species in many areas of southeast Alaska, and shore pine is fed upon heavily in some areas in the vicinity of Haines and Skagway.

In recent sampling of porcupine damage at three sites of Mitkof Island, Sitka spruce was the preferred species and western hemlock was also commonly damaged. Both yellow-cedar and western redcedar were present as minor components of these young 15-25 year-old stands. Feeding was minimal on both cedar species, consisting of wounds where porcupines had apparently tasted and then rejected the tree for further feeding. This brief tasting appears to be the manner in which porcupines select trees for extensive feeding. Thus, yellow-cedar and western redcedar may be a good species to manage for timber values in areas where extensive porcupine damage is expected.

CEDAR DECLINE

Yellow-cedar is suffering from the most spectacular forest decline in western North America. Based on our mapping during our annual insect and disease surveys, this decline now covers more than 500,000 acres of unmanaged forest throughout southeast Alaska. Within the natural range of yellow-cedar, decline is either absent or not severe further to the northwest along the Gulf of Alaska or south through British Columbia to the Oregon-California border.

Paul Hennon, Terry Shaw, and Everett Hansen have cooperated on researching the ecology, epidemiology, and pathology of cedar decline since 1981. Ground surveys show that yellow-cedar is the principal victim of this decline as it is experiencing a disproportionate rate of mortality compared with other conifers. An average of 65% of yellow-cedar's basal area is dead on these sites (Hennon et al. 1990b). Most surveys were conducted on Baranof and Chichagof Islands where decline is severe, but some forests with western redcedar were surveyed on Wrangell and Prince of Wales Islands. Decline is associated with poorly drained soils; yellow-cedar trees that grow on productive, well drained sites have been unaffected (Hennon et al. 1990b, 1992). Several methods were used to date the death of cedar trees to determine when decline began. Results indicate that decline was initiated around 1880, a date supported by historical accounts and also the widespread occurrence of decline on the first available aerial photographs taken in 1927 (Hennon et al. 1990b,c). Most of the trees that died over 100 years ago are still standing today in 1992 and appear as limbless, barkless snags. Thus, the extreme decay resistance of yellow-cedar has allowed for long persistence of dead trees and provided the opportunity to reconstruct the onset and development of decline. Spread of mortality from one site to another has apparently not occurred since onset, but local encroachment ($< 1\text{m/yr}$) has been documented by ground surveys and the use of aerial photographs (Hennon et al. 1990b,c). Where decline spreads locally, it encroaches from its origins in bog and semi-bog communities to affect adjacent forest along a gradient to better drainage.

Symptoms of yellow-cedar decline suggest a below-ground or root problem (Hennon et al. 1990d). Crowns die as a unit, rather than with scattered individual dying branches. Crown death is sometimes sudden resulting in trees with a full, but reddish-brown, complement of foliage. Slow death with gradual thinning of proximal foliage throughout the crown for 10 years or more is more typical of declining cedars. Dying trees rarely recover. Root symptoms include dead fine roots (apparently the initial symptom), dead small diameter roots, and necrotic lesions on larger roots. Narrow necrotic cambial lesions often spread from dead roots up the bole of trees in final stages of death.

Biotic factors are not the primary cause of decline (Hennon et al. 1990d). The only common insects on dying cedars are *Phloeosinus* spp bark beetles. They frequently attack the cambium and phloem of cedars in late stages of decline, but are clearly secondary due to their inability to attack healthy trees. Over 50 taxa of fungi have been collected or isolated from yellow-cedar (Hennon 1990), including *Armillaria* sp., but none has the capability to kill unstressed trees (Hennon et al. 1990d).

Phytophthora spp. were intensively evaluated in cedar decline because the fungus *P. lateralis* is the cause of the fatal root disease of another *Chamaecyparis* spp., Port Orford-cedar. A species of *Phytophthora*, *P. gonapodyides* (Petersen) Buisman, was infrequently isolated from baits placed beneath yellow-cedar trees (Hansen et al. 1988, Hennon et al. 1990d). The fungus was never isolated directly from cedar tissues, however, even though a *Phytophthora*-selective medium was used. It too is not the primary cause of cedar decline, as it lacked strong pathogenicity on yellow-cedar (Hansen et al. 1988).

Four genera of parasitic nematodes were found in declining yellow-cedar forests, but their low populations and occurrence in healthy forests indicate that they do not cause decline (Hennon et al. 1986). Viruses and mycoplasmas, which are unlikely threats to conifers, are currently under investigation in a grafting study at Anita Bay on Etolin Island.

Basal scars (discussed above), once thought to be a symptom of decline, are caused by the Alaska brown bear (*Ursus arctos*) (Hennon et al. 1990a). More than half of yellow-cedars in many stands are wounded. Wounding is not the primary cause of decline, however, as scar incidence is not

greater on dying trees than healthy trees, nor is it greater on cedars in declining stands than in healthy stands (Hennon et al. 1990a).

Although local spread of mortality, the host specificity, and some symptoms suggest a possible pathogen-caused disease, the research conducted to date does not support the hypothesis that any biotic factor is the primary cause of decline. Abiotic factors, probably associated with the wet, poorly drained sites, likely incited this extensive decline. The remote locations, early date of onset, and pristine condition of these areas suggest that cedar decline is a naturally occurring phenomenon. Future research will investigate the causal role of abiotic factors, such as soil toxins and freezing damage.

The lack of a contagious biotic cause and lack of site-to-site spread since the onset of decline should provide managers with confidence that they can establish yellow-cedar plantations on productive sites without threat of the decline factor causing future mortality.

FUTURE MANAGEMENT CONSIDERATIONS FOR YELLOW-CEDAR

Why manage yellow-cedar?

The merits of managing for yellow-cedar were discussed by the group. Yellow-cedar is an important resource on the Tongass National Forest because:

- ▶ it has an economically valuable wood for sawtimber
- ▶ it adds to forest biodiversity
- ▶ it has significant subsistence use
- ▶ it has local use in trail construction
- ▶ it has firewood use
- ▶ it has wildlife use
- ▶ old veteran trees contain valuable information regarding past climates
- ▶ it may have use as an indicator species of certain site characteristics
- ▶ we know so little about its ecology, it has potentially unforeseen importance.

With these important resource factors in mind, we discussed goals of managing yellow-cedar in southeast Alaska. A Forest Plan biodiversity goal is to maintain populations of yellow-cedar at the site and landscape level. Site-specific management goals included maintaining genetic diversity, different age classes, wildlife habitat, highly used subsistence areas, and forest product values. These goals can be achieved by preservation of current yellow-cedar forests, by ensuring adequate regeneration (including the introduction to new sites where yellow-cedar is not currently growing), or some combination of these. A better understanding of the ecology and silviculture of yellow-cedar is critical for good management; thus, new and continuing research on the species is encouraged.

Is current yellow-cedar regeneration meeting desired goals?

The group had a long discussion on the how much natural regeneration of yellow-cedar is occurring on clearcut sites. Several participants had observed some units where yellow-cedar seedlings or saplings were growing and competing well with other vegetation. These isolated cases were primarily located on the Stikine Area and Thorne Bay Ranger District. The Sitka Ranger District had almost no yellow-cedar regeneration in clearcut units. Even on districts where yellow-cedar regeneration occurs at some locations, silviculturists and ecologists have the impression that it is less frequent than is desirable.

Participants agreed that we need a better measure of where natural regeneration of yellow-cedar is occurring and where it is not. Thus, we need to quantify yellow-cedar regeneration by district and sites within districts to clearly identify its status. One participant recommended that regeneration surveys provide the tool for quantifying regeneration of yellow-cedar. Tom DeMeo mentioned that reports from these surveys are not often prepared. Jerry Boughton suggested that a standardized method of survey and reporting exists in the manual and should be used for this purpose. Jay Kittams mentioned that the time to assess yellow-cedar stocking might be best done during precommercial thinning contract preparation exams at about stand age 3 to 5 years. Yellow-cedar and western redcedar are easily distinguishable at that age due to the persistence of immature foliage on yellow-cedar.

Methods to improve regeneration.

The group also discussed a range of silvicultural techniques that may enhance regeneration of yellow-cedar. This was a brainstorming session where ideas were listed without constraint and then discussed for merit or promise. Several advantages and disadvantages were noted for most methods.

1. *Harvest timing.* Conduct harvest at a time to coincide with a heavy cone crop of yellow-cedar. Also, conduct harvest over snow to protect advanced regeneration of yellow-cedar. Timing harvests in these ways may be difficult administratively.
2. *Group selection and small clearcuts.* Harvesting which results in small openings (e.g., < 2 acres) might encourage regeneration by seedfall from perimeter trees. One advantage is the potential for enhancing sites for other resources (e.g., fish and wildlife). Disadvantages include operational and future management costs, possible windthrow losses, and a probable increase in hemlock regeneration. This method may cause too little soil disturbance and create too little light to be effective for yellow-cedar. The size of the opening might influence success.
3. *"Strip" clearcutting.* Using a cable system, either skyline or with slackline carriage, or using trackloader (shovel yarding), harvest a strip (approximately 100 to 200 feet wide) up or down slope. Natural regeneration may benefit from close proximity of seed trees, and blowdown could be harvested by removing additional leave strips. Disadvantages would include stand fragmentation, hemlock establishment, and costs of small units.
4. *Individual tree selection.* As in group selection, this may not result in adequate soil disturbance or increased light to improve regeneration for yellow-cedar. It will probably favor hemlock regeneration. Other disadvantages include high costs and the perception of high-grading high value trees. This method could include leaving smaller yellow-cedar trees in a position so that they would be commercial in the future.
5. *Seed tree harvest.* Leave scattered individual yellow-cedar trees on a unit while harvesting to ensure seed source. This method has low cost and the advantage of improving visuals of the harvested unit due to increasing structure. Leaving the valuable cedar trees on the site, however, would diminish the profitability of the sale. There is a component of genetic improvement with seed tree harvest, if trees with superior traits serve as the seed source. There is some concern about blowdown, but trees only have to remain standing for several years to contribute to regeneration. It may even be advantageous if some or most seed trees blow down after several years. Because the crowns of yellow-cedar are sparse, these trees are less likely to blow down than Sitka spruce or western hemlock (Harris 1989).

6. *Shelterwood harvest.* More or less the same technique as above (No. 4), but with more trees remaining to protect regeneration (e.g., protection from drought and frost). In general, regenerating yellow-cedar does not need protection in the cool moist environment of southeast Alaska. A protective canopy would probably reduce growth by yellow-cedar seedlings due to less light and soil warming and may favor competition by western hemlock. It may also decrease snow on the ground in winter and, thus, encourage deer use in the area resulting in increased browse on yellow-cedar seedlings.

7. *Cedar groups or 'islands' left in clearcuts.* Again, this is similar to seed tree harvest but, with this method, seed trees are left in groups or "islands" in the unit. This may have advantages of wind-firmness and preserving wildlife habitat, but would be less effective in distributing seed across the unit. Future harvesting of groups could be costly. Also, leaving the groups would represent more initial loss as more high value trees are left.

8. *Clearcut and plant.* This is one technique in which we already have some experience. Advantages are that planting can be accomplished successfully on most sites, spacing can be controlled, site preparation can be used, new sites (where yellow-cedar did not previously grow) can be established, and there is a component of genetic control. Disadvantages are the efforts associated with seed and cone collection and storage, expense of producing and planting seedlings, and potential for increased damage to seedlings caused by animals (over natural regeneration).

9. *Clearcut and no planting.* The size of clearcuts may influence natural regeneration of yellow-cedar. Smaller cutting units have relatively more perimeter area; adjacent old-growth yellow-cedar may contribute seed. More yellow-cedar can be left along perimeters by careful unit layout, but then high value trees will not be harvested. Advantages include adequate light, low cost, and no need for site preparation. Disadvantages include unpredictable levels of natural regeneration and little genetic control. The relatively short dispersal distance of yellow-cedar seed should be considered if perimeter yellow-cedar is relied upon as a seed source. By definition, a clearcut is greater than 2 acres in size.

10. *Clearcut and burning.* As site preparation, burning can increase the ease of planting and thinning; reduce competition by hemlock and other vegetation; eliminate hemlock dwarf mistletoe, increase light, temperature, and nutrients for seedlings; and limited data suggest that planted yellow-cedar seedlings perform very well on burned sites. Disadvantages of burning are cost, the limited training by Tongass National Forest personnel, narrow burning windows of time that result in diminished ability to accomplish the burn, the killing of advanced regeneration of yellow-cedar and Sitka spruce, and the unknown long-term effects. Limited data suggests that burning may increase deer browse on yellow-cedar seedlings.

11. *Other site preparation and yarding.* Yum, tractor, or shovel yarding, and various slash treatments could increase soil and vegetation disturbance or effect slash, either of which could have positive or negative effects on naturally regenerated or planted yellow-cedar. Limited data from the Anita Bay trials suggest that deer browsing on planted yellow-cedar seedlings is reduced in areas where abundant slash is left. Harvesting over snow, as mentioned above, could preserve yellow-cedar advanced regeneration where it is present (e.g., wet, poorly-drained sites), but may be difficult operationally and costly.

12. *Favor yellow-cedar during thinning.* Most Districts on the Tongass National Forest already employ this method. Saplings of yellow-cedar (and western redcedar) have high priority for being selected as leave trees during precommercial thinning (often at about stand age 15 years). This

method requires that yellow-cedar natural regeneration or planted seedlings are present on the site. Cost is insignificant.

13. *Utilize natural regeneration on low-volume sites.* Natural regeneration, usually in the form of vegetative layering, is common on sites with relatively poor drainage. As these sites receive more harvesting, this method may be used to encourage more cedar in the next stand. We don't currently know what types of harvest, yarding, or slash treatment and what level of disturbance can optimize the use of natural regeneration on these sites.

14. *Seed tree harvest and burning.* A combination of seed tree harvesting and fire site preparation was proposed by Paul Hennon. Instead of clearcutting a site, scattered well-formed yellow-cedar trees (good phenotypes) could be marked to remain after the rest of the stand is harvested. Essentially, this would be a seed-tree harvest. The site would then be allowed to dry after harvesting and it would be burned at the first good opportunity in summer when a reasonably good cone crop exists. Cutting units with cedar slash are known to produce good burns. Since yellow-cedar has thin bark, as do all tree species in coastal Alaska, the burn would likely kill the seed trees along with the hemlock and most other vegetation. But the seed in cones would probably continue to mature and be dispersed in September and October. The seed would be dispersed to the ground and be free to germinate and grow on a nutritious seedbed with minimal competition. The remaining high value cedar trees, dead or alive, could be harvested several years after the burn, although this may be costly on remote sites if machinery had to be transported.

Another approach would be to use the above seed tree harvest method, but without burning. Ideally, several burn/no burn treatments could be used in an experimental design to learn which methods are the most productive. The Wrangell Ranger District appears interested in attempting this method on Wrangell Island. Tom DeMeo will attempt similar treatments in the Ketchikan Area.

Pruning and spacing.

The group had a brief discussion about the merits of pruning once a site has been regenerated. Pruning can improve the quality and value of wood products; it can also increase the time that forage for wildlife persists before canopy closure. Bill Farr and a graduate student are currently investigating the costs and effects of pruning and thinning of spruce and hemlock. Many results should be applicable to yellow-cedar management. In general, pruning is considered expensive, but new devices may make it more economically practical. Stem pruning may solve major deficiency of young-growth grown in plantations for timber--excessive limbs and subsequent knots in wood. No work has been conducted on yellow-cedar, although foresters in British Columbia are considering pruning their yellow-cedar plantations. They believe that yellow-cedar will have high value if a portion of the bole is free of knots. Along with extended rotations and density control, relatively clear boles may be achieved by pruning. Spacing will have various affects on wood quality too. Advantages of low stand density are faster radial growth, few re-entries (lower cost), and enhancement of wildlife habitat. Advantages of high stand density are smaller limbs, tighter grain, and a higher valued wood product. We agreed to keep communicating with our contacts in B.C. to stay in touch with their current thinking and information.

Research needs.

The most urgently needed applied research is on what factors limit successful regeneration of yellow-cedar. Other research on aspects of cedar decline are still needed such as determining the resource of dead cedar on the Tongass National Forest, studying the feasibility of salvage, evaluating the potential abiotic causes of decline, and determining methods of regeneration and site rehabilitation for declining stands. Once we better understand regeneration and refine its application, information will be needed

on the management of yellow-cedar on different sites. We will need knowledge on how spacing, mixed species-stands, drainage, animal damage, etc. affects wood quality and other resource values.

For regeneration, research is needed in the areas of:

1. *Seed*. Basic information is needed on production, viability (in nature and in storage), periodicity (frequency of peak and low years of seed production), predation mortality, and dispersal distance. Is minimal seed production or some aspect of its germination the primary factor for poor regeneration on most sites?
2. *Soil requirements*. What soil factors are required for seed germination, establishment, and good growth? In particular, what are the effects of different forms of disturbance on natural regeneration? Do different soil microsites influence survival and growth of planted seedlings? How does burning a site affect natural or artificial regeneration of yellow-cedar?
3. *Light requirements*. How shade tolerant is yellow-cedar? Is shade intolerance the reason that it does not regenerate more commonly naturally in small gaps? Is natural regeneration affected by aspect (e.g., more light on south slopes)?
4. *Temperature*. Do seedlings need protective canopy (e.g., shelterwood) for optimal establishment or is open growing conditions best?
5. *Harvest (disturbance) treatments*. How will different silvicultural systems such as single tree selection, group selection, shelterwood, seed tree, and clearcutting affect regeneration. In other words, what is the optimal *size or configuration* for tree or stand harvesting that encourages natural regeneration by allowing adequate light (larger area) and proximity of seed source (smaller area)? How do these various harvest (regeneration) systems differ economically? To what degree is competing vegetation affected by each treatment? How is the success of regeneration by these treatments affected by plant association type? Many of these questions will be addressed by a proposed study that Tom DeMeo will be initiating on the Ketchikan Area and John Stevens and others in comparing different harvest methods and site preparation treatments on the Wrangell Ranger District.
6. *Animal damage*. How damaging are different levels of animal feeding (primarily deer) on yellow-cedar regeneration (natural regeneration and planted seedlings). Is tree form subsequently affected as a result of top-feeding on seedlings by deer?
7. *Advanced regeneration*. Can vegetative reproduction (layering) that occurs on wet sites be encouraged to grow into trees of the next stand? Can seedlings or saplings be used on sites with better drainage?
8. Is *cedar decline* a threat to plantations of yellow-cedar? What is the best method of regenerating a site that currently expresses decline (e.g., should species other than yellow-cedar be used)? Are there surviving yellow-cedar trees on decline sites that are genetically resistant to the decline factor?

What can we do now?

Finally, the group discussed measures that can be used right now to improve the regeneration and management of yellow-cedar.

1. Ensure that yellow-cedar management is appropriately considered by silviculturists developing

site-specific vegetation management prescriptions as part of interdisciplinary teams and the NEPA process.

2. Planting. Continue to consider planting yellow-cedar on appropriate sites. Monitor seedling survival, growth, and deer browse so that we learn the best methods and site selection for planting.
3. Thinning contracts. Continue to encourage favoring yellow-cedar during thinning operations (usually precommercial thinning). Contracts can be written to adjust spacing when the desired species (yellow-cedar) is encountered by thinners. Take the time to educate thinners about the importance of yellow-cedar. A standardized precommercial thinning contract for the region with site specific flexibility would ensure prescribed treatments are achieved.
4. Aggressively monitor cone crops and make collections as soon as possible using existing Regional seed zones. Refine seed zones so that appropriate stock is planted by all districts. Ensure yellow-cedar seed needs are appropriately identified on Forest/Area 10-year seed need plans. Collect seed from trees which have desirable phenotypic traits.
5. Observe and monitor natural regeneration along clearcut edges, in stands receiving alternative management, and anywhere else to improve our perceptions about where natural regeneration can be used. Also note damage by deer browse on regeneration in these areas. These observations can be shared at a future cedar meeting and informally among foresters.
6. Develop a timber type in GIS for a yellow-cedar type or a vegetative map unit using plant associations.
7. Develop guidelines for management of yellow-cedar.
8. Use the existing plant association system for reporting all observations of yellow-cedar.
9. Collect more information or use current data to determine where natural regeneration by yellow-cedar on clearcut sites is occurring and where it is not.
10. Maintain close contact with scientists and silviculturists in British Columbia who are working with yellow-cedar. In general, efforts at yellow-cedar regeneration and management of yellow-cedar in British Columbia are well ahead of those in Alaska. We have much to gain from sharing information.
11. Encourage close working relationships among silviculturists, ecologists, and other resource specialists on the Tongass National Forest on all aspects of yellow-cedar management and biology.
12. Prescriptions. Well thought out, professionally prepared prescriptions will include the objectives, treatments, and monitoring needs of yellow-cedar.
13. Support use of the common name, yellow-cedar.
14. Develop a Data General mailing list so that all personnel can share ideas, observations, and news regarding yellow-cedar. This mailing list has now been developed; it is called CEDAR:R10A. Contact Paul Hennon if you want your name added or removed from the list.

In general, participants left the meeting with a greater appreciation for the importance of yellow-cedar and with the understanding that there are many opportunities for considering its management. Participants appeared to be motivated to meet the challenge of increasing our knowledge and actively managing this important forest species.

ACKNOWLEDGEMENTS

I am grateful to Jon Martin for helping with the planning of the yellow-cedar workshop, organizing the field trip, and facilitating the discussions. I thank Rick Hauver for taking notes during our field trip. I also thank Jerry Boughton, Jay Kittams, Bill Pawuk, Tom DeMeo, Bill Dougan, John Stevens, Thom Pence, Jerry Jordan, and Dean Argyle for many helpful comments and suggestions on a draft of this report.

REFERENCES

- Alaback, P.B. 1992. Yellow cypress: an overview of biology and evolution. Proceedings of Yellow cypress-can we grow it? Can we sell it? Mar. 26-28, 1990. Vancouver, B.C. (In press).
- Andersen, H.E. 1959. Silvical characteristics of Alaska-cedar (*Chamaecyparis nootkatensis*). USDA For. Ser., Alaska For. Res. Center Sta. Pap. 11. 10p.
- Antos, J.A.; Zobel, D.B. 1986. Habitat relationships of *Chamaecyparis nootkatensis* in southern Washington, Oregon, and California. Can. J. Bot. 64: 1890-1909.
- Dunsworth, B.G.; Steele, L. 1987-1991. Yellow-cypress working group newsletter. Numbers 1-5. MacMillan Bloedel Limited, Nanaimo, B.C., Canada.
- El-Kassaby, Y.A.; Maze, J.; MacLeod, D.A.; Banerjee, S. 1991. Reproductive-cycle plasticity in yellow-cedar (*Chamaecyparis nootkatensis*). Can. J. For. Res. 21: 1360-1364.
- Fowells, H.A. 1965. Silvics of forest trees of the United States. USDA For. Ser., Washington, D.C., Agric. Handb. No. 271:546-556.
- Grossnickle, S.C. 1992. Physiological and environmental tolerances of yellow cypress. Pp. 30-32. In: Proceedings of Yellow cypress-can we grow it? Can we sell it? Mar. 26-28, 1990. Vancouver, B.C. (In press).
- Hamm, P.B.; Hansen, E.M.; Hennon, P.E.; Shaw, C.G. III. 1988. *Pythium* species from forest and muskeg areas of southeast Alaska. Trans. Brit. Mycol. Soc. 91: 385-388.
- Harris, A. 1969. Alaska-cedar, a bibliography with abstracts. USDA For. Ser., Pac. NW For. and Range Exp. Sta. Res. Pap. PNW-73. 47p.
- Harris, A. 1971. Alaska-cedar. American Woods. USDA Forest Service FS-224. Washington, DC. 7p.
- Harris, A. 1989. Wind in the forests of southeast Alaska and guides for reducing damage. USDA For. Ser., Pac. NW For. Res. Sta., Portland OR, Gen. Tech. Rep. PNW-GTR-244. 63p.
- Harris, A. 1990. *Chamaecyparis nootkatensis* (D. Don) Spach Alaska-cedar. Pp. 97-102. In: Silvics of North America, Vol. 1. USDA For. Ser. Ag. hanb. 654. 675p.
- Hansen, E.M.; Hamm, P.B.; Shaw C.G. III; Hennon, P.E. 1988. *Phytophthora drechsleri* in remote areas of southeast Alaska. Trans. Brit. Mycol. Soc. 91: 379-388.
- Hennon, P.E. 1990. Fungi on *Chamaecyparis nootkatensis*. Mycologia 82(1):59-66.
- Hennon, P.E.; Hansen, E.M.; Shaw, C.G. III. 1990a. Causes of basal scars on *Chamaecyparis nootkaensis* in southeast Alaska. Northwest Science 64(2): 45-54.
- Hennon, P.E.; Hansen, E.M.; Shaw, C.G. III. 1990b. Dynamics of decline and mortality of *Chamaecyparis nootkatensis* in southeast Alaska. Can. J. Bot. 68: 651-662.
- Hennon, P.E.; Newcomb, G.B.; Shaw, C.G. III; Hansen, E.M. 1986. Nematodes associated with dying *Chamaecyparis nootkatensis* in southeast Alaska. Plant disease 70:352.
- Hennon, P.E.; Shaw, C.G. III; Hansen, E.M. 1990c. Dating decline and mortality of *Chamaecyparis nootkatensis* in southeast Alaska. Forest Science 36: 502-515.

- Hennon, P.E.; Shaw C.G. III; Hansen, E.M. 1990d. Symptoms and fungal associations of declining *Chamaecyparis nootkatensis* in southeast Alaska. *Plant disease* 74: 267-273.
- Hennon, P.E. 1991. Survival, growth, grazing, and shoot blight of planted yellow-cedar seedlings in southeast Alaska. USDA For. Ser. Juneau, AK. FPM Gen. Tech. Rep. R10-TP-20. 14p.
- Hennon, P.E. 1992. Diseases, insects, and animal damage of yellow cypress. *Proceedings of Yellow cypress-can we grow it? Can we sell it?* Mar. 26-28, 1990. Vancouver, B.C. (In press).
- Hennon, P.E., Shaw, C.G. III, and Hansen, E.M. 1992a. Reproduction and forest decline of *Chamaecyparis nootkatensis* in southeast Alaska. *Proceedings of V International Congress of Ecology*. Aug. 23-30, 1990. Yokohama, Japan. In review.
- Hennon, P.E.; Shaw, C.G. III, and Hansen, E.M. 1992b. Cedar decline: ecology and epidemiology of its decline in southeast Alaska. In: *Forest declines*, ed. P. Manion. American Phytopathological Society. St. Paul, MN. In press.
- Heusser, C.J. 1960. Late-Pleistocene environments of the North Pacific North America. American Geographical Society, New York. 308p.
- Jozsa, L.A. 1990. Yellow-cypress trivia. Yellow-cypress working group newsletter. Feb. 1991. MacMillan Bloedel, Nanaimo, Canada.
- Karlsson, I.; Russell, J. 1990. Comparisons of yellow cypress trees of seedling and rooted cutting origins after 9 and 11 years in the field. *Can. J. For. Res.* 20: 37-42.
- Little, E.L. Jr. 1979. Checklist of United States trees (native and naturalized). U.S. Dep. Agric., Agric. Handb. 541, 375p.
- Lousier, J.D. 1992. Yellow cypress: can we grow it? can we sell it? *Proceedings of Yellow-cypress symposium*. March 26-28, 1990., Richmond, B.C., Canada. W.F.S. Enterprises Ltd., Nanaimo, B.C. In press.
- Owens, J.N.; Molder, M. 1984. The reproductive cycles of western redcedar and yellow-cedar. Victoria, B.C. Ministry of Forests, Forestry Division Research Branch. 28p.
- Perry, R.S. 1954. Yellow cedar; its characteristics, properties, and uses. Can. Dep. of Northern Affairs and Nat. Res. For. Branch, Bull. 114. Ottawa, Canada. 19p.
- Pielou, E.C. 1991. *After the ice age: the return of life to glaciated North America*. Univ. Chicago Press, Chicago IL. 366p.
- Sato, K. 1973. *Chamaecyparis obtusa* in Japan. Zenkoku Ringyou Kairyou Hukyou Kyoukai, Tokyo, Japan. (In Japanese).
- Zobel, D.B.; Roth, L.F.; Hawk, G.M. 1985. Ecology, pathology, and management of Port-Orford-cedar (*Chamaecyparis lawsoniana*). USDA For. Ser., Pac. Northwest For. Res. Sta., Portland OR., Gen. Tech. Rep. No. 184. 161p.

APPENDIX A. List of participants who attended the yellow-cedar workshop on November 20-22, 1991 at Sitka, Alaska.

<u>Name</u>	<u>Position</u>	<u>Location</u>
Annette Anderson	Forestry Technician	Craig RD
Kent Barkhau	Silviculturist	Sitka RD
Jerry Boughton	Silviculturist	RO, Juneau
Tom DeMeo	Ecologist	Ketchikan SO
Bill Dougan	Silviculturist	Sitka SO
Rick Hauver	Silviculturist	Ketchikan SO
Paul Hennon	Pathologist	S&PF/FSL, Juneau
Rich Jennings	Silviculturist	Petersburg RD
Jerry Jordan	Forestry Technician	Wrangell RD
Everett Kissinger	Soil Scientist	Stikine SO
Jay Kittams	Silviculturist	Stikine SO
Jon Martin	Ecologist	Chatham SO
Phil Mullen	Forester	Wrangell RD
Bill Pawuk	Ecologist	Stikine SO
Thom Pence	Silviculturist	Juneau RD
Ken Rollins	Silviculturist	Thorne Bay RD
Jim Russell	Silviculturist	Chatham SO
John Stevens	Silviculturist	Wrangell RD
Jim Tambling	Forstry Technician	Hoonah RD
Pat Tierney	Silviculturist	Thorne Bay RD
Randy West	Soil Scientist	Chatham SO

APPENDIX B. Field Trip Notes.

First Stop: Mary Calvin's wood lot

This stand is on a mixture of low and medium quality sites near Sitka. The low site is a mixed conifer blueberry plant association. The medium site is a hemlock-cedar blueberry association. The stand is now about 140 years old and originated when Russians hand-logged the stand. The myay have used the wood for building materials, for the construction of boats, or in making charcoal. By basal area, the stand is comprised of about 60% yellow-cedar and 40% Sitka spruce and western hemlock. The basal area was high and the stocking was considered good.

Diameters of dominant yellow-cedars ranged were often around 12 to 14 inches in diameter, with the largest class about 20 inches. Height of yellow-cedars was about 60-70 feet. The dominant spruce were about the same size as the dominant yellow-cedars. It was noted that the hemlock in this stand was heavily infected with dwarf mistletoe. The dwarf mistletoe probably slowed hemlock growth and may have given the cedar an edge in competing with the hemlock for growing space.

The dense stocking probably helped maintain a smaller branch size. Most trees had dead branches extending from 6-8 feet above their base to live crown at about 30-40 feet up their bole. Pruning some time ago probably would have resulted in clear boles and a greatly increased value.

Someone asked, "how did the good yellow-cedar stocking happen on this site?" Jon Martin hypothesized that Russian hand logging removed only small patches at a time. Today's harvest removes sizable clearcuts every season. Also, cull (but still live) yellow-cedar may have been left to provide a seed source. Jon continued to explain his deer/cedar regeneration hypothesis. Jon noted that in old-growth, open-canopy cedar stands, cedar regeneration was absent. Jon thought the lack of regeneration was the result of deer browsing. He pointed out that deer did not have an impact on the cedar stocking at this site. The Russians and Natives, through subsistence hunting, would have kept the deer populations very low around the Sitka town site.

Several people commented that there was no yellow-cedar regeneration on the forest floor under this stand. Jon felt that the lack of regeneration was due to the lack of sun light reaching the forest floor. The above canopy was very dense. Closer examination resulted in the finding of several newly-germinating yellow-cedar seedlings. But no sizable seedlings or saplings were found.

Upon departing the stand, the group stopped examined a 50 foot-wide power pole right-a-way. There was good yellow-cedar regeneration in this opening. That seemed to support that yellow-cedar regeneration needed overhead light, and as in the time of the Russians, current deer populations around Sitka continue to be low and they have no impact on yellow-cedar regeneration.

Second Stop: Tim William's lot

This stand was located in Sitka on a medium quality site with a hemlock-cedar blueberry plant association. The site was more productive than the previous stand. The stand originated from cutting about 105 to 110 years ago. The stand had a higher basal area of spruce and hemlock (60%) than yellow-cedar (40%). Several residuals of each tree species were present from the previous stand.

The yellow-cedar's lower branches were larger diameter than those found on the yellow-cedars at the Carter wood lot. Lower stocking at the William's lot may have accounted for the poorer self-pruning that was occurring in this stand. As in the previous stand, the hemlocks were heavily infected with dwarf mistletoe.

Paul Hennon talked about brown bears stripping yellow-cedar bark in the spring when bark is easily removed and the cambium is sweet. Bears may be licking the cambium for sugars, although that has never been documented. One large survey had 49% of the stems stripped by bears. A question was asked about stripping and defect. Stripping creates large wounds that allow for the entry of wood decay fungi into stems. The heartwood of yellow-cedar is resistant to decay, but the sapwood is not. Patterns of decay were found in wounded boles that were dissected (see references: Hennon et al. 1990, Northwest Science).

We next looked at a building lot that was cleared about 30 years ago next to the stand. The clearing was still in a brush-conifer state; crowns had not closed and blueberry and herbs were abundant. Most of the regeneration was western hemlock which was about 7-8 feet tall. Yellow-cedar regeneration mixed with the hemlock and was about 4-5 feet tall.

Last stop: Hill side above town

This was a high quality site dominated by large Sitka spruce and western hemlock. The stand originated from cutting in about 1859. The stand is now about 120-130 years old. Yellow-cedar is absent in the stand. It was either absent in the previous stand or was present and unable to regenerate or compete with spruce and hemlock on this productive site. Jon Martin commented that, although this stand is not very old, it is already acquiring some of the attributes of old-growth stands, most notably snags. The definition and conditions attributed to old-growth stands were discussed.